DIGITAL DATA ACQUISITION GRAPHICAL USER INTERFACE

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ABSTRACT

Traditional radioxenon measurements have been done by ground-based fixed systems, however in recent years there has been an increased need for systems capable of quick deployment or even complete mobility. Using the Pixie-4 data acquisition (DAQ) system can help reduce the electronics footprint of both current systems, like the radioxenon Radionuclide Laboratory 16 (RL-16) and the Swedish Automatic Unit for Noble Gas Acquisition (SAUNA), as well as future systems. Pacific Northwest National Laboratory (PNNL) has developed a Linux based Nyx graphical user interface (GUI) for Pixie-4 cards. The Nyx software can be installed on various Linux platforms and is written in C++. This software offers a rich user interface for configuring and operating the Pixie4 card and PNNL designed high voltage (HV) cards.

Nyx allows one to quickly get a nuclear detector operational by maintaining the core diagnostic features built into the Pixie-4 cards. First, Nyx maintains the multitude of adjustable parameters accessible in the Pixie-4 cards, which allows one to customize settings to take full advantage of a particular detector. Nyx also maintains an oscilloscope feature which is extremely useful to optimize settings and to verify proper detector behavior and is often the first feature used in Nyx during detector setup. Finally, Nyx allows the user to collect data in several formats including full pulse shapes to basic histograms. Overall, it is the corner stone for the transition of beta-gamma systems to a state-of-the-art digitizing DAQ system.

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OBJECTIVES

Ground-based nuclear explosion detection systems currently available range from particulate to radioxenon samplers. There are now several detector packages available to the community in support of nuclear explosion treaty monitoring. These detectors range from β–γ (Reeder, 1998; Cooper, 2005; Cooper, 2007) to high purity germanium (HPGe) detectors, however, despite the differences in detectors, they all have signals that need to be read out and processed. Many of the fielded radioxenon and particulate systems use a combination of CAMAC and NIM. Although these electronics are very flexible they do have fairly large footprints, taking up as much as 45” tall by 24” wide by 31” deep.

Switching to new compact electronics will reduce the physical footprint and also significantly improve the DAQ capabilities through the ability to perform digital signal processing. However, the new data acquisition systems, like those produced by X-ray Instrumentation Associates (XIA) (XIA 2010), do create an interface problem for systems using a Linux operating system. The original systems designs have DAQ interfaces which will need to be reworked for new electronics to be useable. Currently the XIA based Pixie-4 cards (Hennig et al., 2007) run on only Microsoft (MS) Windows operating system (OS), which uses commercially available software as the interface. Since many Radioxenon systems are now using Linux based operating systems, PNNL has developed a Linux based GUI, called Nyx, for the Pixie-4 cards and National Instruments (NI) crate.

RESEARCH ACCOMPLISHED

The Nyx GUI (Schrom, 2009) is a useful tool for rapidly optimizing detector settings and acquiring the measurement data. It uses a number of open source compilers and libraries including Boost (Boost, 2010) and Qt (Qt, 2010) and is written entirely in C++. Nyx uses a modular design, which makes code changes easier by separating the components such as hardware access, the control logic and the graphical user interface. Nyx has been tested under several Linux platforms including Ubuntu, Debian, and Red Hat Enterprise Linux and has shown to be portable between Linux systems.

Nyx uses a tabbed environment to give easy access to each portion of the DAQ. It is organized into sections following a typical experimental flow: setup, configuration, and nuclear detector operation. The High Voltage (HV) tab contains adjustments for the HV. The tab also displays the actual voltage that each channel is set for, allowing some voltage diagnostics of detector performance. The Settings tab is as stated; it is where the user adjusts the majority of the parameters to optimize the signal acquisition from a given detector. The other configuration parameters are a little less straight forward, and control the signal triggering and integration.

Settings Configuration

Configuration parameters that need to be specified are trigger filters, energy filters, thresholds, and coincidence masks and windows. Figure 1 shows the channel sub-tab from on the settings tab. The trigger and energy filters are set based on a typical pulse from the detector of interest. The trigger parameter needs to be set to maximize the number of real pulses triggered as opposed to triggering on noise or missing a real pulse. Typically the threshold is set to reduce or eliminate the noise; it is normal to allow some noise events to be triggered in order to maximize real signal pulses processing. Usually the small amount of noise in the data does not impact the data quality. The energy filter, on the other hand, needs to have the rise time set to match a typical detector pulse rise time, which can be seen in Figure 2. In this particular case, the zoomed in portion of Figure 2 shows the rise time is approximately 0.5 μs. The flat top should be set to be longer than the rise time, however the longer the flat top the better detector energy resolution (maximum flat top length is often determined by the count rate).

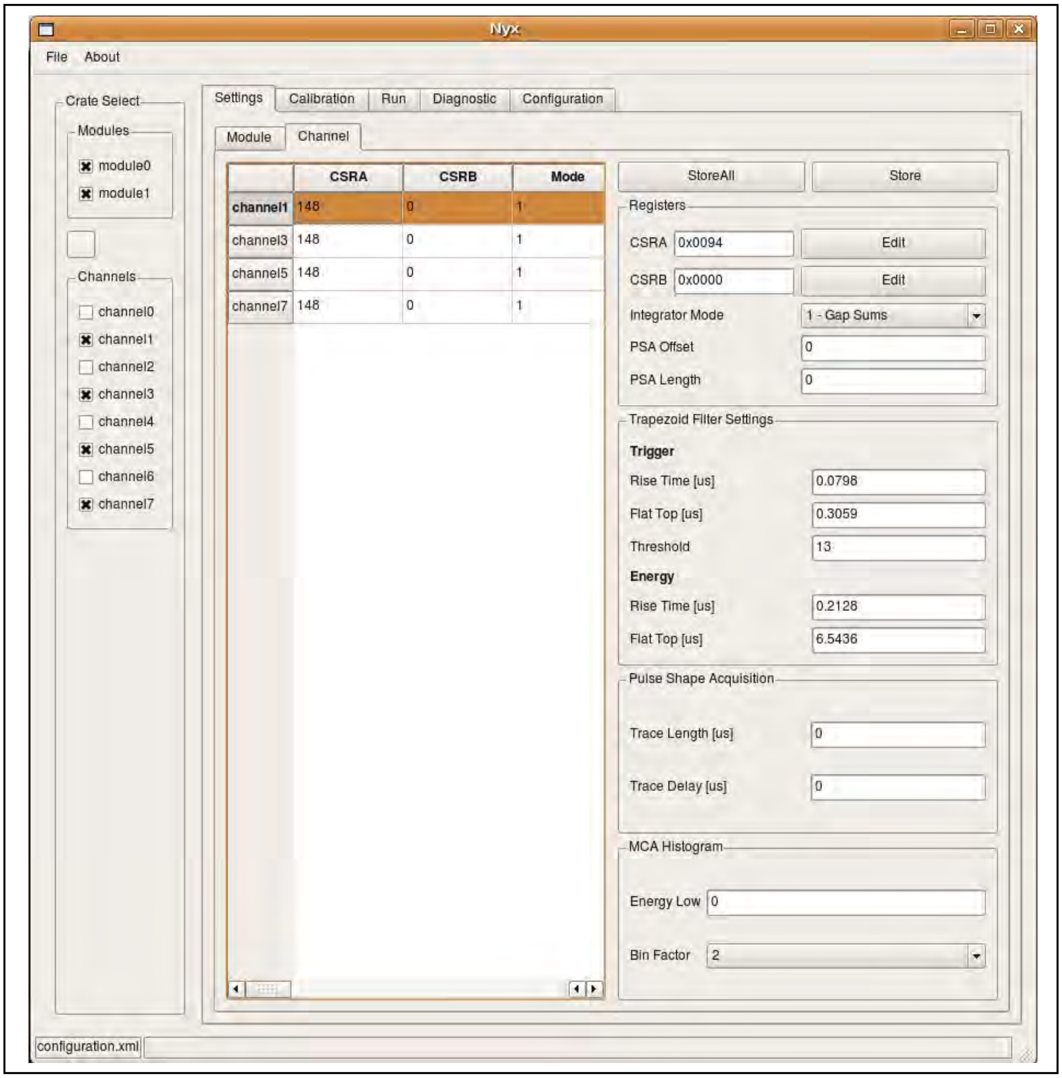

Figure 1. A screenshot of the Nyx settings tab.

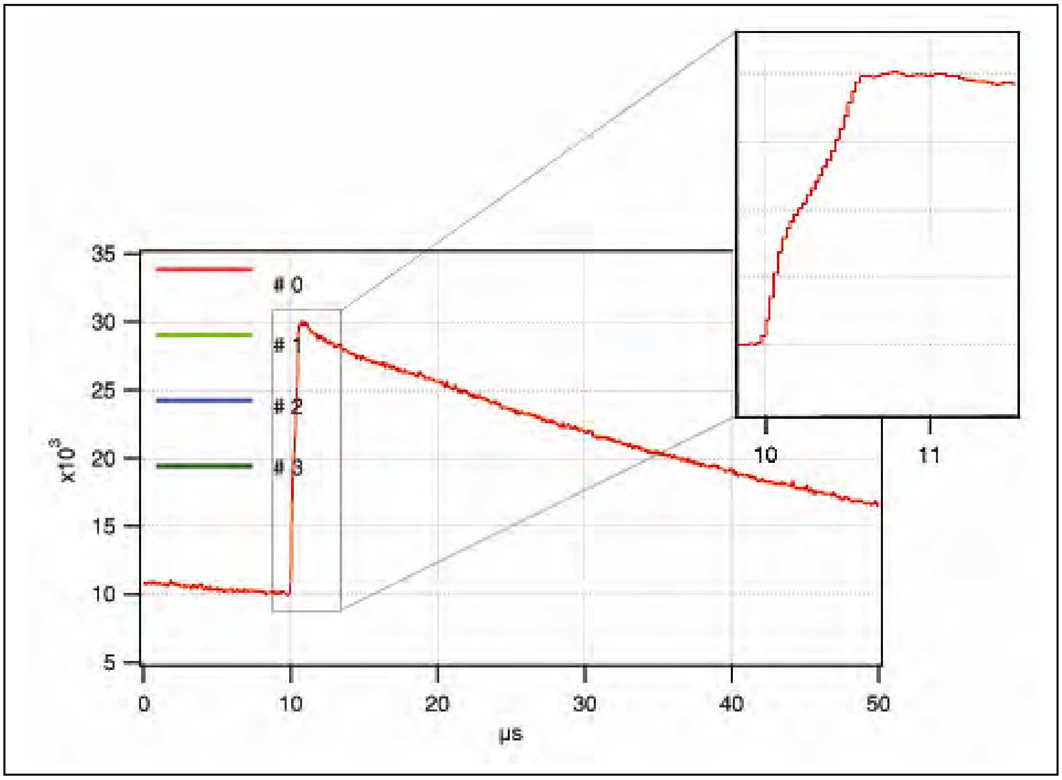

Figure 2. An example of a signal pulse that may be used to set the energy filter.

The second tab section, calibration, enables the researcher to match the dynamic range of the input signal with appropriate gain adjustments. An “oscilloscope” window allows untriggered sampling to capture traces, which are fit to find the preamplifier decay time constant, tau. Figure 3 shows a magnified pulse where tau is being fit using an exponential function built into the fitting routine of the Nyx software. This display also gives an indication of the amount of noise on the input signals. The noise level is indicated by how much variation (peak to peak) there is when a signal pulse is absent. This information can be used as an additional check on threshold settings; however it is usually best to empirically determine the optimal threshold by making several measurements.

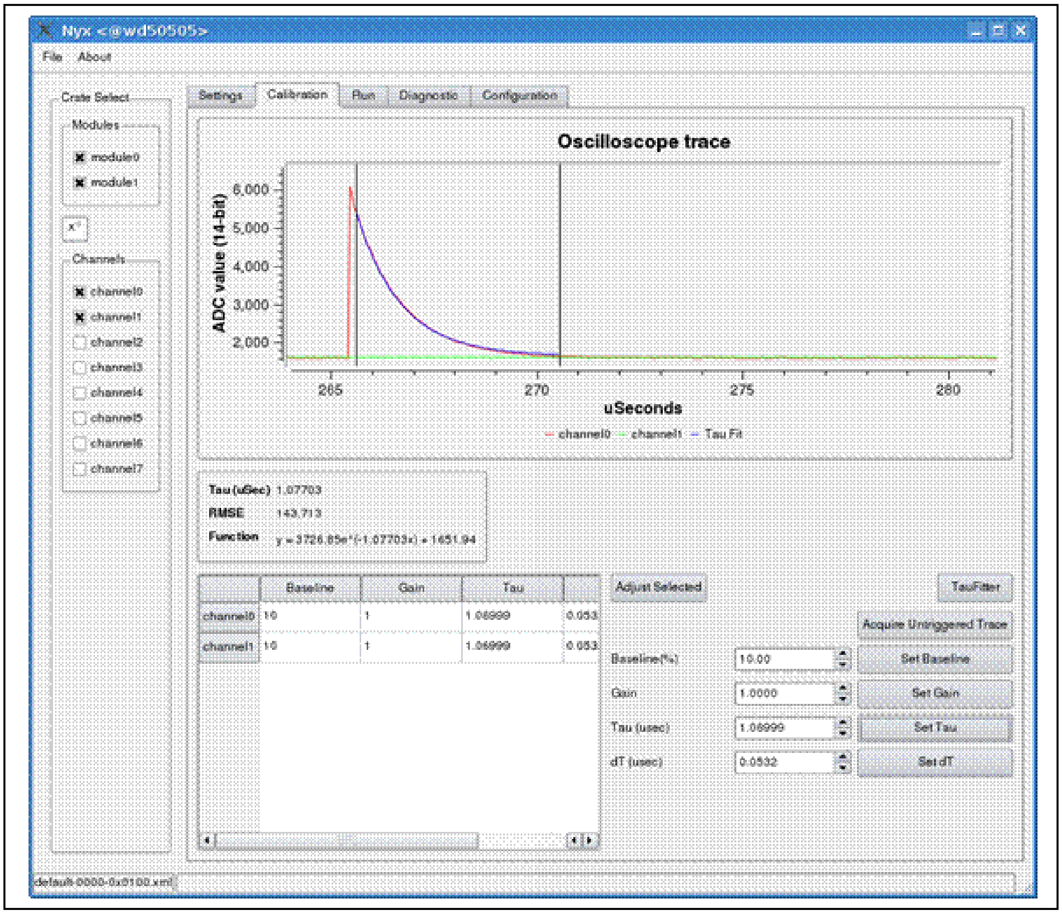

Figure 3. A screenshot of the Nyx calibration tab.

Data Acquisition

The third tab section, Run, controls the data acquisition. A data collection run can acquire the data in histogram mode, list mode or trace data mode. Each data mode uses progressively more storage space, with the trace data using a very large amount of storage. The histogram mode is generally used for either detector diagnostics or for simple experiments. The list mode is often used for experiments that are well characterized, but require some post acquisition processing. Finally, the trace data saves pulse information (shown in Figure 2) and is used in measurements where a sophisticated analysis and post processing is required. For example the trace data mode has been used for pulse shape analysis (Knoll, 1996; Lee, 1999; Gatti 1999; Vetter 2000; Aalseth 2000; Aalseth 2008) of both HPGe for spatial resolution and phoswich research (Farsoni, 2007; Hennig 2005), where a fast beta signal needs to be resolved from a slow gamma signal. Trace data is also frequently taken during initial setup to help determine parameter settings.

During a run there are several real time diagnostic tools available. On the run tab, the count rate and livetime/deadtime can be monitored by clicking on the refresh stats button located 2/3 of the way down the window. This is important to check to ensure the deadtime is not too high (>20%), which may indicate poor data quality or parameters that require further optimization. The other frequently monitored data are the histograms which appear on the diagnostic tab (see Figure 5). Often these are used to make sure the data is being collected properly.

Independent of the data mode being used; a run can be stopped by a particular event or action. Measurements can be stopped at a specified number of recorded events, elapsed time and also by manual stop. At the conclusion of each run, a file set containing the raw data, the complete state of the hardware (including parameter values) and the meta-data for the run is archived. The meta-data includes: parameters from the card, from the system, and parameters that the researcher input for later reference. The archive file can be read in by the Nyx software to load

the settings from that a particular run in order to repeat that measurement and is a typical method for setting the parameters. Figure 4 is a screen capture of the Run window showing typical settings for a run collecting trace data.

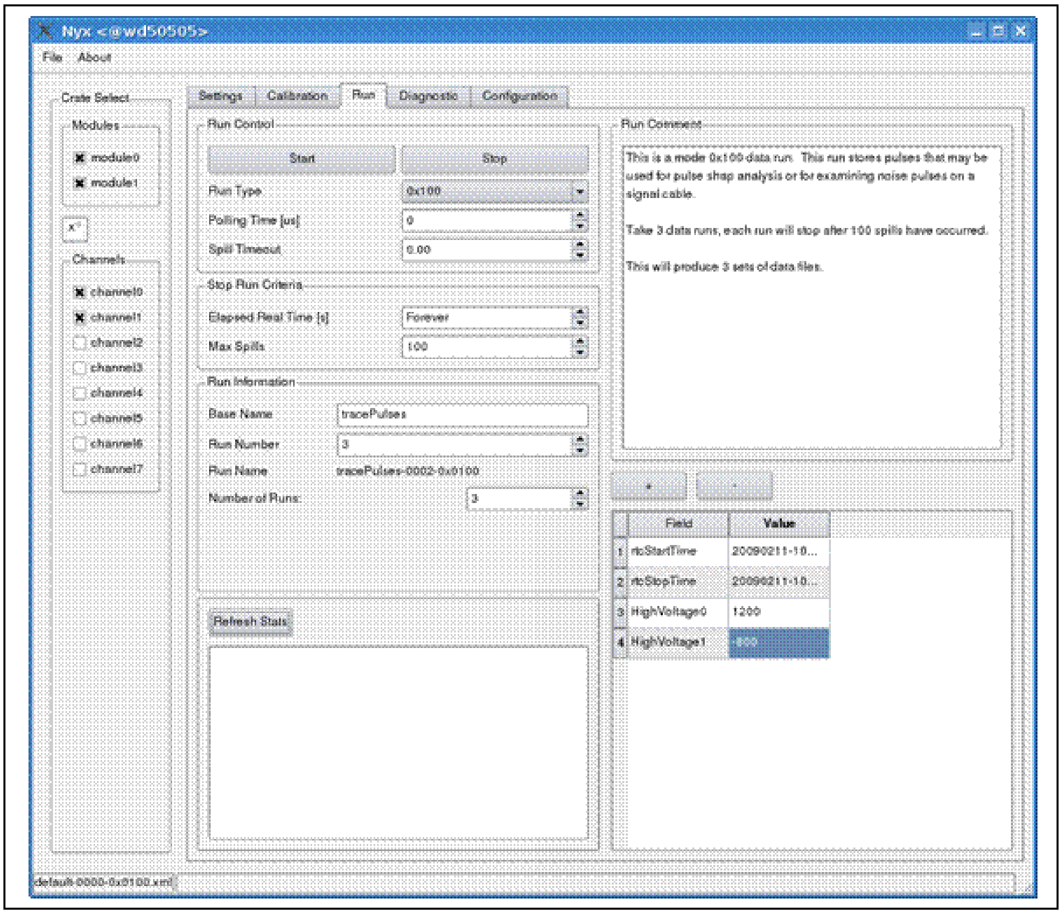

Figure 4. A screenshot of the Nyx run tab.

The fourth tab section, Diagnostic, is for preliminary data analysis that can be used to assess the configuration and operation of the detector. The analysis tools in this section use simplified algorithms (such as a basic Gaussian fitting routine) that are suitable for ensuring valid operation but are not meant for rigorous data analysis. This includes an individual pulse viewer for fine-tuning lower level thresholds and a histogram viewer for verifying both energy resolutions and gain matching. Figure 2 shows a captured pulse in the pulse viewer, while Figure 5 shows the 661.7-keV peak from ^{137}Cs in the histogram before the peaks have been aligned. Aligning the peaks can be done using the gain settings (in the Calibration tab) or adjusting the HV.

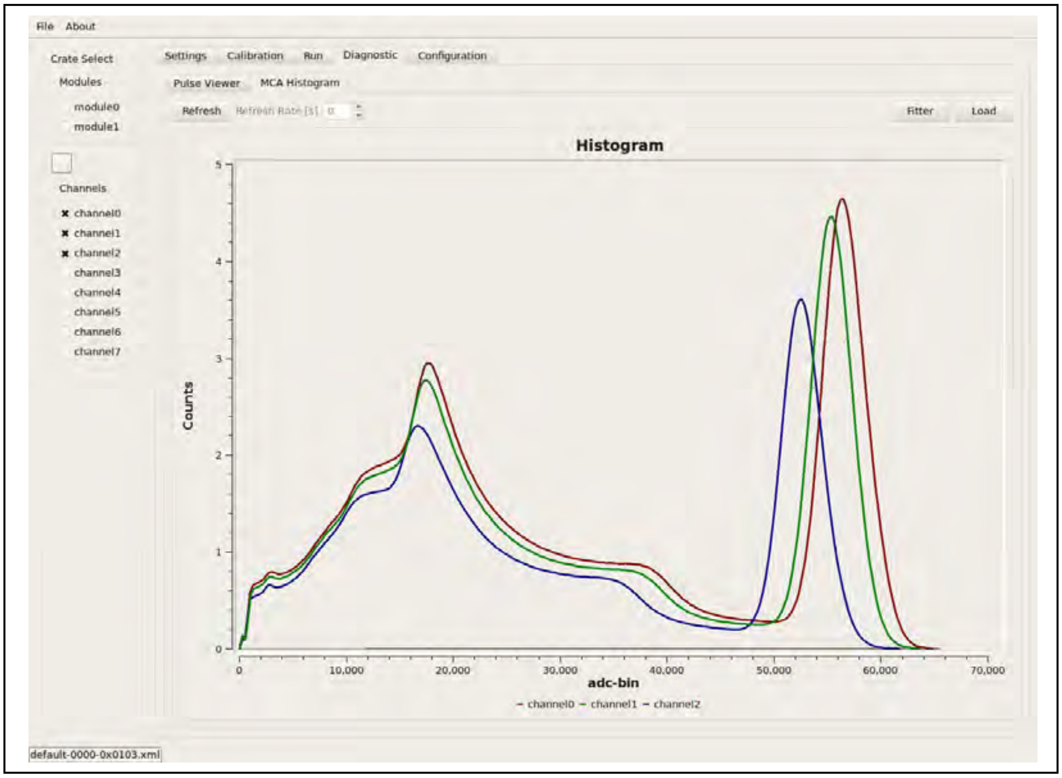

Figure 5. A screenshot of the Nyx diagnostic tab showing ^{137}Cs spectra.

Other Features

The fifth tab, Configuration, is intended for advanced users and will not be discussed in this paper. Finally, one of the commonly used user interface features, which appears independently of which tab is selected, is the module and channel selections. The modules and channels selections are always visible. They allow the user to select what will be displayed on a given screen. For instance, if only one channel has a histogram of interest, then only that channel is selected (checked). This ability to only display selected channels or modules is important when several different detector styles are being used. Each detector will need to be configured independently from the others, so displaying only the channel that is currently being optimized is extremely useful. This transparency, visibility, and selectability makes setting up channels simple and less error prone than other methods whether there are several identical or unique channels.

CONCLUSIONS AND RECOMMENDATIONS

XIA has improved the Pixie4 card by packaging it in a compact peripheral component interconnect (cPCI) bus connector that fits in a National Instruments crate. Pacific Northwest National Laboratory developed a complimentary four channel HV card that fits the same cPCI form factor. The matching HV and data acquisition cards result in a compact multichannel data acquisition system with pulse digitization and large data storage capability. The form factor of the NI crate, Pixie-4 cards and PNNL developed HV cards allows what used to be a physically very large data acquisition system to now be only 8” x 8” x 12” without losing any functionality.

Nyx is the interface with the DAQ system and allows the user to have complete control of the nuclear detector. Nyx interfaces with the Pixie-4 and HV cards, allowing the user to optimize the detectors signal for any particular detector type/style. Nyx maintains a strong emphasis on signal processing and has several tabbed screens to set run parameters. The Nyx software provides fully functional list-mode and pulse-shape data collection, which is critical for applications that either do post processing, pulse shape analysis or pulse shape discrimination. Nyx is a valuable resource for Linux based systems that need a small, yet powerful, DAQ system.

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